



## Conference Paper

# Nanostructuring of Surface Layer of 1.3505 Steel By Wedge Cylindrical Tool

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## Abstract

This paper discusses the issues of normal load during burnishing by a wedge cylindrical tool that influences the surface hardening of the 1.3505 steel according to the criteria of microhardness and thickness of nanostructured layer. It has been established that burnishing with a normal force of 200 and 250 N provides formation of a nanostructured layer with a 4,3...5,5  $\mu\text{m}$  thickness and a maximum microhardness of 1120...1170 HV<sub>0,05</sub>.

**Keywords:** nanostructure, surface layer, hardening, burnishing, wedge cylindrical tool, bearing steel.

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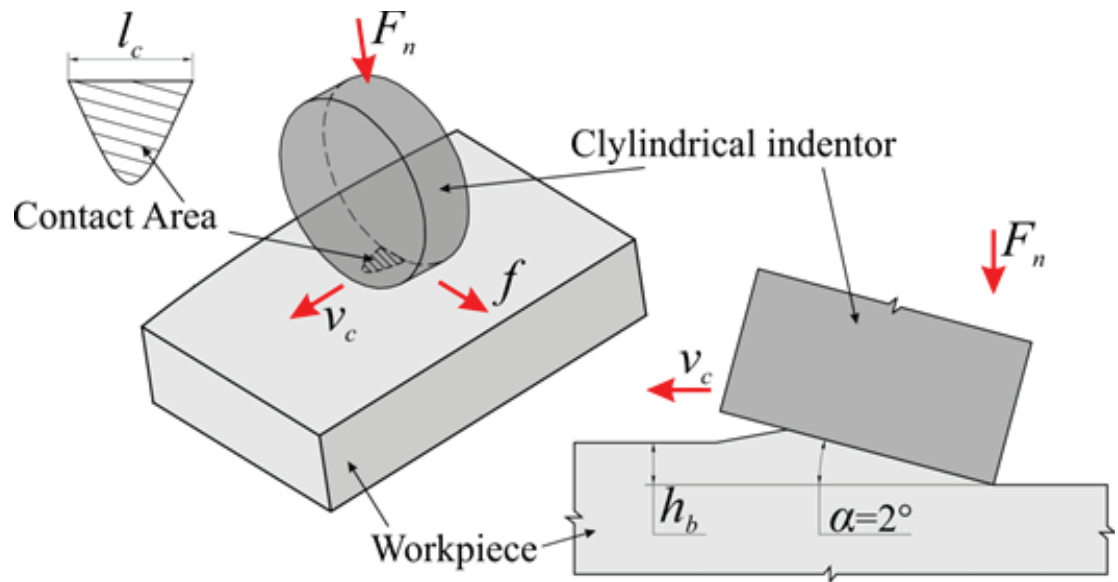
## 1. Introduction

There is a known perspective technology of forming the nanostructured surface layer of structural steels during sliding of spherical indenter [1-2]. However, the conducted study showed that when using the spherical indenter on the rear relatively to the direction of sliding, the formation of tensile stresses of high level takes place. These stresses negatively influence the quality of forming surface [2]. Similar effect occurs due to indenter's clearance.

It has been known that when using the wedge cylindrical indenter, this effect practically disappears [3-4]. Thus, it is particularly important to develop the technology of forming the nanostructured surface of bearing steels during sliding of wedge indenter.

Within the framework of this paper, it is suggested to conduct burnishing using the cylindrical indenter with the angle of  $2^\circ$  to the surface of a workpiece (fig. 1). As a result of normal load with the force  $F_n$ , indentation takes place at a depth  $h_b$ . The formed contact patch has a parabolic form with the width of footing  $l_c$ .

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**Figure 1:** The scheme of burnishing a workpiece by wedge cylindrical tool.

In order to study the surface nanostructuring by wedge cylindrical indenter, a special tool was fabricated that uses a replaceable hard-metal insert SECO RNMN090300S-02020 from boron nitride CBN500 as a working part.

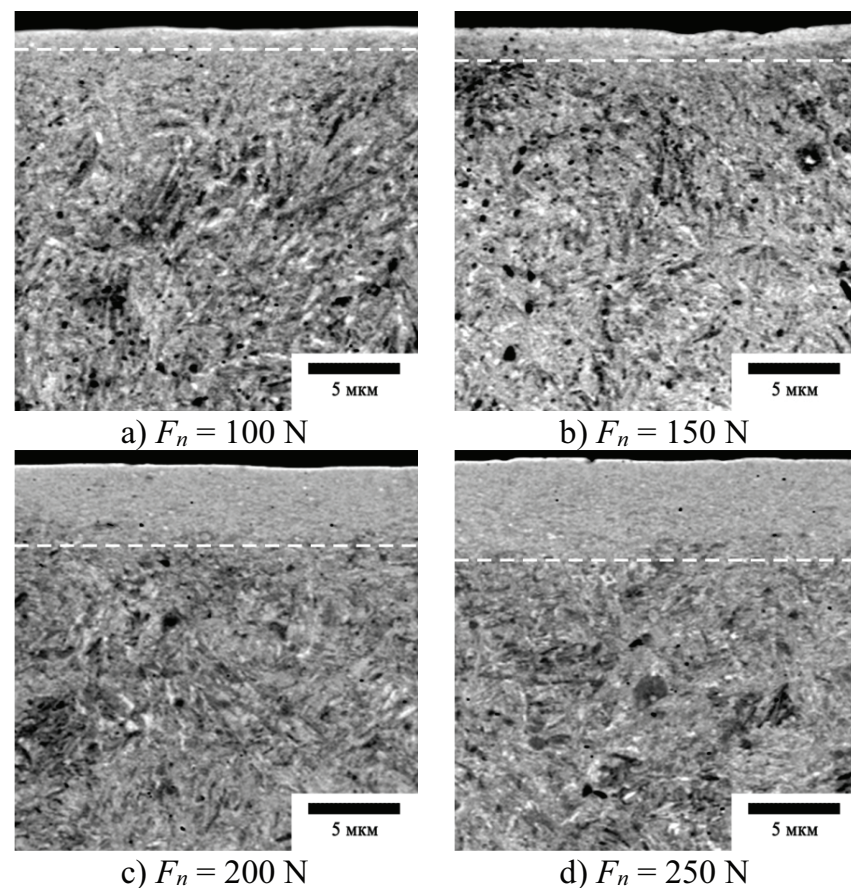
The aim of the work is to define the influence of normal load on structure formation and microhardness of surface layer of bearing steel 1.3505 during burnishing by wedge cylindrical tool.

## 2. Experimental Setup

Experimental study was conducted on the samples of type “disc” of 1.3505 steel of 90 mm diameter and thickness of 12 mm. Samples underwent heat treatment at 830 °C and letting down at 300 °C. After these operations their hardness was 56...57 HRC. In order to provide surface flatness before burnishing, finish turning at a velocity of 80 m/min and feed of 0,08 mm/rev were performed. The cutting depth was 0,2 mm. An arithmetic average of profile deviation of the surface after turning process was  $R_a = 0,8 \mu\text{m}$ .

The burnishing of ring tracks with the width of 15 mm with different normal force for each: 100, 150, 200, and 250 N was performed on the sample. The sliding velocity was established at a level of 25 m/min, the feed – 0,04 mm/rev. Burnishing was performed during the feeding of oil-cooling processing medium FUCHS into the processing zone.

In order to prepare cross-sections from processed tracks using electroerosion machine AgieCut Sprint 20, the samples of 20x10 mm in size were cut. The surface under study was grinded and polished using the diamond suspension.



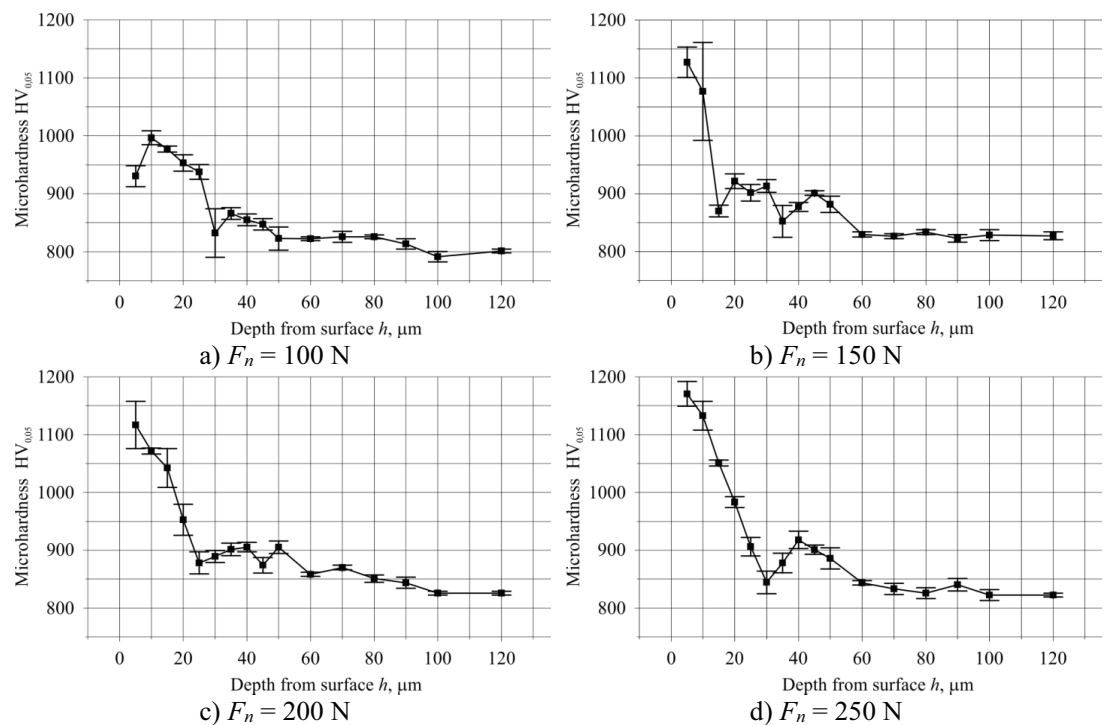
**Figure 2:** Microstructure of the surface layer after burnishing with different normal force.

### 3. Results and Discussions

The microstructure of the surface layer was studied using scanning-electron microscope Zeiss GrossBeam AURIGA. The analysis of received images (fig. 2) showed that when burnishing by wedge cylindrical tool, the formation of nanostructured surface is provided. With normal force of 100 and 150 N the thickness of nanostructured layer is 1,2...1,6  $\mu\text{m}$ . The increase of normal force to 200 and 250 N leads to the increase in thickness of the layer to 4,3 and 5,5  $\mu\text{m}$  accordingly.

Microdurometry in depth of the surface layer was conducted using the microhardness measuring tool Leica VMHT on the reconstructed indentation of Vicker pyramid with load of 0,05 kgf. Measurements were taken at a depth below the surface of 5...50  $\mu\text{m}$  with the interval of 5  $\mu\text{m}$ , at a depth of 50...100  $\mu\text{m}$  with the interval of 10  $\mu\text{m}$  and the next one with the interval of 20  $\mu\text{m}$ . The measurements were stopped when the microhardness of parent matrix of the material was reached. The values of microhardness were defined as an arithmetic average out of 5 successive indentions of the pyramid at equal distance from the surface.

The achieved results show that the formation of the layer with microhardness of more than 1000 HV<sub>0,05</sub> requires the normal force of more than 150 N. In case of burnishing with the force of 100 N, the microhardness reaches the values close to 1000 HV<sub>0,05</sub> at distance of 10 μm from the surface and do not exceed the mentioned level (Figure 3, a). During burnishing with the force of 150 and 200 N the maximum microhardness increases to 1125 HV<sub>0,05</sub>, and the level of more than 1000 HV<sub>0,05</sub> is provided in the layer of 12 and 18 μm thickness accordingly (fig. 3, b and c).



**Figure 3:** The distribution of microhardness in depth of the surface layer of samples after burnishing with differential normal force.

## 4. Conclusions

It may be concluded that burnishing by the wedge cylindrical tool is an effective method of nanostructuring of the surface layer of bearing steels. It has been also established that with the increase of normal force to 250 N, the thickness of nanostructured layer to 20 μm and the maximum microhardness of the surface to 1180HV<sub>0,05</sub> also increases.

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